BASEMENT

LIBRARY
OF THE
MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

HD28
.M414
no 924-77

MASS. INST. TECH.
MAY 18 1977
LIBRARIES

ROBUST REGRESSION AND SENSITIVITY ANALYSIS IN ESTIMATING MUTUAL FUNDS PERFORMANCE 1945 - 1964

by

Oded Berman and Eduardo Modiano*
M.I.T.

Working Paper 924-77 April, 1977

ROBUST REGRESSION AND SENSITIVITY ANALYSIS IN ESTIMATING MUTUAL FUNDS PERFORMANCE 1945 - 1964

by

Oded Berman and Eduardo Modiano*
M.I.T.

Working Paper 924-77 April, 1977

* Under a Fellowship from CNPq (Conselho Nacional de Desenvolvimento Cientifico e Tecnologico- Rio de Janeiro - Brasil)

M.I.T. LIBRARIES
MAY 18 1977
RECEIVED

Abstract

In estimating the performance of mutual funds ordinary least squares regression has been so far the most common statistical tool. In this paper an attempt is made to illustrate the application of a more sophisticated analysis, in particular, sensitivity anlaysis and robust regression. The paper includes results for a sample of 10 funds during the period 1945-1964.

0731210

Acknowledgements

We wish to express our sincere appreciation to Professor Stewart Myers for giving us some of his valuable time, his helpful comments, and encouragement.

We are also grateful to Professor Roy Welsch for his useful suggestions in the early stages of this work.

Introduction

The purpose of this paper is to challenge Jensen's results in his article "The Performance of Mutual Funds in the Period 1945-1964", using more sophisticated modern statistical techniques. These results concluded, from the analysis of 115 funds in the period 1945-1964, that portfolio managers had not superior forecasting capabilities. Out of the 115 funds investigated in the cited paper, 76 funds showed inferior forecasting capabilities.

Our work consists of analyzing a random sample of 10 such funds using sensitivity analysis and robust regression techniques implemented in the TROLL system.

This paper is composed of 7 sections:

Section 1: Derivation of Equilibrium Conditions in the Capital Asset Market.

Section 2: Jensen's Empirical Version of the CAPM

Section 3: The Database

Section 4: Sensitivity Analysis

Section 5: Residuals Analysis and Robust Regression

Section 6: Conclusions and possible Extensions

Section 7: Attachment A

1. Equilibrium conditions in the capital asset market

The theoretical results of the capital asset pricing models were derived independently by Sharpe [5], Lintner [3], Mossin [4], and Treynor [6]. A short derivation of these results based on Mossin [4] is presented below. The purpose of all the above models is to provide a theory of equilibrium of exchange in a market for risky assets and study the properties of this equilibrium.

Mossin assumes that the individual, as in a competitive market is a "price-taker" and has a preference ordering among possible portfolios. The solution of the problem at the individual level implicitly determines its demand for risky assets as a function of prices. The interaction of these individuals' demand schedules, under certain assumptions on the individual and market behavior, determines the prices of assets that equalize supply and demand for all assets.

All the cited models are based on the assumptions that:

a) all investors are risk averse and are single period expected utility of terminal wealth maximizers;

b) all investors have homogeneous expectations regarding investment opportunities. In Mossin this implies all individuals have identical probability distributions of the yields of the different assets;

c) all investors are able to rank portfolios solely on the basis of expected yields and variances. Borch [I] proved that if no assumption is made about the probability distributions of yield, then individuals must have quadratic utility functions for yield. This implies rather unnatural assumptions about the market participants behavior toward risk;

d) there exists a riskless asset and all individuals are able to borrow or lend at the same riskless rate;

e) all transaction costs and taxes are zero;

f) all assets are infinitely divisible. Letting:

n = number of assets

p_j = price per unit of asset j, j=1,...,n-1

$p_n \equiv q$ = numeraire

μ_j = expected yield per unit of asset j, j=1,...,n-1 (μ_n = 1 for the riskless asset)

y_1^i = expected yield on individual i's portfolio

σ_{kj} = covariance of yields of units of assets j and k_j, k=1,...,n-1 ($\sigma_{nk} = \sigma_{kn} = 0$ for all k)

y_2^i = variance of yield on individual i's portfolio

$U^i(\tilde{y}^i)$ = individual i utility for yield

$f^i(y_1^i, y_2^i)$ $E[U^i(\tilde{y}^i)]$ derived utility for expected yield and variance for individual i with $f_1^i \equiv \frac{\partial f^1}{\partial y_1^i} > 0$ and $f_2^i \equiv \frac{\partial f^2}{\partial y_2^i} < 0$

$\bar{x}_j^i$ = before-exchange holdings of asset j in physical units by individual i, j=1,...,n-1, i=1,...,m

$\bar{x}_n^i$ = before-exchange holdings of the riskless asset by individual i

Decision variables:

x_j^i = after-exchange holdings of individual i of risky asset j, in physical units j=1,...,n-1, i=1,...,m

x_n^i = after-exchange holdings by individual i of riskless asset n in physical units, i=1,...,m

Under the above assumptions investor i solves:

$$\max f^i(y_1^i, y_2^i)$$

s.t.

$$(1) \qquad y_1^i = \sum_{j=1}^{n-1} \mu_j x_j^i + x_n^i$$

$$(2) \qquad y_2^i = \sum_{j=1}^{n-1} \sum_{\alpha=1}^{n-1} \sigma_{j\alpha} x_j^i x_\alpha^i$$

$$(3) \qquad \sum_{j=1}^{n-1} p_j x_j^i + x_n^i = \sum_{j=1}^{n-1} p_j \bar{x}_j^i + \bar{x}_n^i$$

Constraint (3) acts like a budget constraint equalizing before exchange and after exchange wealth. Under assumption (a) this is a concave problem over a convex set and the Kuhn-Tucker necessary and sufficient conditions for optimality become

$$(4) \qquad \frac{dy_2^i}{dy_1^i} = \frac{f_1^i}{f_2^i} = \frac{2 \sum_\alpha \sigma_{j\alpha} x_\alpha^i}{\mu_j - p_j/q}$$

$$(5) \qquad \sum_{j=1}^{n-1} p_j (x_j^i - \bar{x}_j^i) + q(x_n^i - \bar{x}_n^i) = 0$$

Solving (4) and (5) for the x_j^i's would determine individual i's demand for the n assets for this set of prices. In market equilibrium we must have equality between supply and demand for all assets.

$$(6) \qquad \sum_{i=1}^{m} x_j^i = \sum_{i=1}^{m} \bar{x}_j^i \equiv \bar{x}_j \qquad j=1,\ldots,n$$

However, the (mn+n) equations (4), (5), and (6) provide one redundant equation. Therefore we are left with (mn+n-1) equations and the unknowns are (mn)x_j^i's and the (n-1) relative prices p_j/q. Counting equations and unknowns is the classical approach to determine where an equilibrium might exist.

Letting $\tilde{r}_j$ denote the rate of return on a unit of risky asset j we have

$$(7) \qquad E[\tilde{r}_j] = \left(\frac{\mu_j}{p_j} - 1\right) \qquad j=,\ldots,n-1$$

$$(8) \qquad r_n = \frac{1}{q} - 1$$

where β_j is a measure of volatility (systematic risk) of the asset j defined as $\beta_j \equiv \text{cov}(\tilde{r}_j, \tilde{r}_M)/\gamma_M^2$ where $\tilde{r}_M = \sum_{j=1}^{n-1} W_j \tilde{r}_j$ is the return on the market portfolio (a weighted average) and γ_M^2 is the variance of the market return.

By corresponding addition in (11) and the fact that

$$\beta_M = 1$$

we obtain the standard format of the asset market line, namely:

$$E[\tilde{r}_j] - r_n = \beta_j (E[\tilde{r}_M] - r_n) \tag{12}$$

This implies that all "fairly" priced assets should lie along this line.

2. Jensen's Empirical Version of CAPM

Equation (12) implies that expected return on any asset is equal to the risk-free rate plus a risk premium given by the product of its systematic risk and the risk premium on the market portfolio.

If a security analyst has "predictive capabilities" and therefore is able to predict future security prices he will be able to earn higher returns than those implied by (12) and the riskiness (β_j) of the portfolio.

However, Eq. (12) is stated in terms of expected returns which are unobservable quantities. Jensen [2] shows how (12) can be rewritten in terms of realized returns on any portfolio j and the market portfolio M. Also important for this study is Jensen's [2] conclusions after testing the single period model in a multiperiod world if β_j's and generating functions are constant.

$$(12') \quad E[\tilde{r}_{jt}] = r_{Ft} + \beta_j[E(\tilde{r}_{Mt}) - r_{ft}]$$

Jensen shows that

$$(13) \quad \tilde{r}_{jt} = E[\tilde{r}_{jt}] + b_j\tilde{\pi}_t + \tilde{e}_{jt} \qquad j=1,\ldots,n-1$$

where b_j is a coefficient approximately equal to the measure of risk β_j and $\tilde{\pi}_t$ is an unobservable "market factor" which affects the returns on all securities. The variables $\tilde{\pi}_t$ and $\tilde{e}_{jt}$ are assumed to be independent normally distributed random variables with

$$E(\tilde{\pi}_t) = 0$$

$$E(\tilde{e}_{jt}) = 0 \qquad j=1,\ldots,n-1$$

$$\operatorname{cov}(\tilde{\pi}_t, \tilde{e}_{jt}) = 0 \qquad j=1,\ldots,n-1$$

$$\operatorname{cov}(\tilde{e}_{jt}, \tilde{e}_{it}) = \begin{cases} 0 & i \neq j \\ \gamma^2(e_j) & i = j \end{cases}$$

Also to a close approximation we will have

$$(14) \quad \tilde{r}_{Mt} \simeq E[\tilde{r}_{Mt}] + \tilde{\pi}_t$$

Substituting (14) and (13) in (12') we are able to express (12') in terms of ex-post returns. Hence (12') reduces to

$$(15) \quad \tilde{r}_{jt} - r_{Ft} = \beta_j[\tilde{r}_{Mt} - r_{Ft}] + \tilde{e}_{jt}$$

which implies that realized risk premiums on any security or portfolio can be expressed as a linear function of its systematic risk realized returns on the market portfolio and a random error $\tilde{e}_{jt}$ such that $E[\tilde{e}_{jt}] = 0$.

If the manager is a superior forecaster he will tend to systematically choose securities with $\tilde{e}_{jt} > 0$. In order to allow for the possibility that the portfolio selected earns more than the normal risk premium given its level of risk we simply regress (15) without constraining to pass through the origin. Hence we estimate

$$(16) \quad \tilde{r}_{jt} - r_{Ft} = \alpha_j + \beta_j[\tilde{r}_{Mt} - r_{Ft}] + \tilde{u}_{jt}$$

where $E[\tilde{u}_{jt}] = 0$.

Therefore we should expect $\alpha_j > 0$ if that portfolio manager has indeed superior forecasting capabilities and the capital asset pricing model holds. At the same time we should expect that random selection of buy and hold should yield a zero intercept ($\alpha_j = 0$). Conversely, if the manager is doing worse than random selection we should expect $\alpha_j < 0$.

Therefore Jensen [2] chose α_j to be a measure of performance of the funds. We should stick to his choice. By using least squares regression theory an estimate of the dispersion of the intercept α_j is obtained which permits evaluating the statistical significances of

the estimates $\tilde{\alpha}_j$ which is, under his assumptions t distributed with n_j-2 degress of freedom.

Definition of the variables

The variables used in estimating α_j and β_j in (16) are defined more precisely below:

$\tilde{S}_t$ = Level of Standard and Poor Composite 500 price index at end of year t

$\tilde{D}_t$ = Estimate of dividends received on the market portfolio in year t measured by annual observations on the four quarter moving average of the dividends paid by the companies in the composite 500 index (stated on the same scale as the level of S & P 500 Index).

$\tilde{r}_{Mt} = \log_e(\frac{S_t+D_t}{S_{t-1}})$ = The estimated annual continuously compounded rate of return on the market portfolio M for year t.

NA_{jt} = Per share net asset value of the j^{th} fund at end of year t.

ID_{jt} = per share "income" dividends paid by the j^{th} fund during year t.

$\tilde{CG}_{jt}$ = per share "capital gains" distributions paid by the j^{th} fund during year t.

$\tilde{r}_{jt} = \log_e(\frac{\tilde{NA}_{jt}+\tilde{ID}_{jt}+\tilde{CG}_{jt}}{NA_{j,t-1}})$ = The annual continuously compounded rate of return on the j^{th} fund during year t, (adjusted for splits and stock dividends). This is net of all management fees and brokerage costs.

r_t = yield to maturity of a one-year government bond at the beginning of year t (obtained from Treasury Bulletin yield curves)

$r_{Ft} = \log_e(1+r_t)$ = annual continuously compounded risk free rate of return for year t.

n_j = number of observations of the j^{th} fund ($10 \leq n_j \leq 20$).

3. The Database

The first stage in our analysis was to reproduce the database that Jensen used in his paper "The Performance of Mutual Funds in the Years 1945-1964" for the funds of our random sample (see Table 1). We used the same sources that Jensen used as recommended in that paper:

1) "Investment Companies, New York: Arthur Wiesenberg & Co." (for getting data for the funds)

2) "Standard and Poor Corporation, Trade and Securities Statistics: Security Price Index Record" (for obtaining data on the market)

3) "Treasury Bulletin" (for the risk free).

We ran least square regression for the ten funds and the results appear on Table 2. A comparison of these results with Jensen's results appears in Table 3. This comparison was not complete since Jensen does not provide in his paper the estimates for β. However, in another paper, "Risk, The Pricing of Capital Assets, and the Evaluation of Investment Portfolios", there are estimates for β, but only for the years 1955-1964 and those are the β in Table 3.

As we can see in Table 3 we did not get exactly the same point estimates although they are very close. The magnitude of the standard deviation of $\hat{\alpha}$ only strengthens our decision that the differences are not significant.

Jensen's ID Number	Name	Number of Observations
168	Composite Fund, Inc.	15
198	Incorporated Investors	20
206	Istel Fund, Inc.	11
218	Massachusetts Life Fund	16
220	Mutual Investment Fund, Inc.	18
224	National Securities - Dividend Series	14
236	The George Putnam Fund of Boston	20
249	Television Electronics Fund, Inc.	16
253	United Science Fund	14
1191	Group Securities - Aerospace Science Fund	14

Randomly Selected Open End Mutual Funds

Table 1

2: R168-RFT = A+B*(RMT-RFT)

NOB = 15 NOVAR = 2
RANGE = 1950 TO 1964
RSQ = 0.91237 CRSQ = 0.90563 F(1/13) = 135.34
SER = 0.0303 SSR = 1.190E-02 DW(0) = 2.02

COEF	VALUE	ST ER	T-STAT
A	-0.00396	0.00982	-0.40347
B	0.59524	0.05117	11.63380

2: R198-RFT = A+B*(RMT-RFT)

NOB = 20 NOVAR = 2
RANGE = 1945 TO 1964
RSQ = 0.94178 CRSQ = 0.93855 F(1/18) = 291.1
SER = 0.0495 SSR = 4.405E-02 DW(0) = 2.14

COEF	VALUE	ST ER	T-STAT
A	-0.06101	0.01361	-4.48214
B	1.27541	0.07474	17.06390

2: R206-RFT = A+B*(RMT-RFT)

NOB = 11 NOVAR = 2
RANGE = 1954 TO 1964
RSQ = 0.90638 CRSQ = 0.89598 F(1/9) = 87.132
SER = 0.0423 SSR = 1.610E-02 DW(0) = 2.42

COEF	VALUE	ST ER	T-STAT
A	0.01545	0.01532	1.00820
B	0.71708	0.07682	9.33447

2: R220-RFT = A+B*(RMT-RFT)

NOB = 18 NOVAR = 2
RANGE = 1947 TO 1964
RSQ = 0.92091 CRSQ = 0.91597 F(1/16) = 186.804
SER = 0.0336 SSR = 1.811E-02 DW(0) = 2.72

COEF	VALUE	ST ER	T-STAT
A	-0.03370	0.00996	-3.38447
B	0.76129	0.05578	13.64930

Table 2

2: R224-RFT = A+B*(RMT-RFT)

NOB = 14 NOVAR = 2
RANGE = 1951 TO 1964
RSQ = 0.75912 CRSQ = 0.73905 F(1/12) = 37.818
SER = 0.1201 SSR = 0.173 DW(0) = 2.44

COEF	VALUE	ST ER	T-STAT
A	-0.05281	0.03911	-1.35029
B	1.28227	0.20851	6.14965

2: R236-RFT = A+B*(RMT-RFT)

NOB = 20 NOVAR = 2
RANGE = 1945 TO 1964
RSQ = 0.88847 CRSQ = 0.88228 F(1/18) = 143.395
SER = 0.0388 SSR = 2.714E-02 DW(0) = 1.75

COEF	VALUE	ST ER	T-STAT
A	-0.00721	0.01068	-0.67472
B	0.70248	0.05866	11.97480

2: R249-RFT = A+B*(RMT-RFT)

NOB = 16 NOVAR = 2
RANGE = 1949 TO 1964
RSQ = 0.51341 CRSQ = 0.47866 F(1/14) = 14.772
SER = 0.1552 SSR = 0.337 DW(0) = 2.60

COEF	VALUE	ST ER	T-STAT
A	-0.00824	0.04959	-0.16609
B	1.00809	0.26229	3.84340

2: R253-RFT = A+B*(RMT-RFT)

NOB = 14 NOVAR = 2
RANGE = 1951 TO 1964
RSQ = 0.89048 CRSQ = 0.89002 F(1/12) = 106.205
SER = 0.0597 SSR = 4.276E-02 DW(0) = 1.88

COEF	VALUE	ST ER	T-STAT
A	-0.02516	0.01943	-1.29442
B	1.06789	0.10362	10.30560

Table 2 (Cont'd.)

2: R1191-RFT = A+B*(RMT-RFT)

NOB = 14 NOVAR = 2
RANGE = 1951 TO 1964
RSQ = 0.71749 CRSQ = 0.69395 F(1/12) = 30.476
SER = 0.1456 SSR = 0.254 DW(0) = 1.85

COEF	VALUE	ST ER	T-STAT
A	-0.08209	0.04739	-1.73213
B	1.39501	0.25270	5.52052

Table 2 (Cont'd.)

1: R218-RFT = A+B*(RMT-RFT)

NOB = 16 NOVAR = 2
RANGE = 1949 TO 1964
RSQ = 0.86535 CRSQ = 0.85573 F(1/14) = 89.774
SER = 0.0322 SSR = 1.451E-02 DW(0) = 2.04

COEF	VALUE	ST ER	T-STAT
A	-0.00398	0.01028	-0.38734
B	0.51682	0.05449	9.48548

Table 2 (Cont'd.)

Fund	Jensen's Estimates			Our Estimates			
	$\hat{\alpha}$	$\sigma(\hat{\alpha})$	$\hat{\beta}$	$\hat{\alpha}$	$\sigma(\hat{\alpha})$	$\hat{\beta}$	$\sigma(\hat{\beta})$
168	-.0022	.01	.594	-.00396	.0098	.595	.0511
198	-.0615	.0127	1.262	-.0610	.0136	1.2754	.074
206	.0165	.015	.716	.0154	.0153	.7170	.0768
220	-.0332	.0121	.821	-.03370	.0099	.7612	.055
224	-.0411	.0238	1.085	-.0528	.0391	1.282	.2085
236	-.0050	.0108	.704	-.0072	.0106	.7024	.0586
249	-.0155	.0209	1.060	-.00824	.04959	1.00809	.2622
253	-.0249	.0199	1.065	-.02516	.0194	1.0678	.10362
1191	-.0805	.050	1.409	-.08209	.0473	1.395	.2527
218	-.0014	.01	.512	-.00378	.0102	.5168	.0549

Comparison Between Jensen's Least Square Regression and Our Paper's Results

Table 3

4. Sensitivity Analysis

Any least squares regression model contains many assumptions like independence, homoscedasticity, error distribution, etc. There are some classic methods to check these assumptions, and the model builder should use them. In addition the output of the model is a consequence of the input (the data) that is used. Therefore it seems essential that the model builder should investigate also what changes of the output of the model would be the result of perturbing the data, or in other words, performing sensitivity analysis.

The ideal situation should be that a slight input perturbation would lead to small output changes.

In this paper we decided to analyze changes in the parameter estimates $(\hat{\alpha},\hat{\beta})$ when observations for one year are deleted from the time series. We shall describe first in more detail the sensitivity analysis approach, and then analyze the results that we obtained with our model.

The Sensitivity Analysis

The model that we investigate is

$$r_{jt}-r_{Ft} = \alpha_j + \beta_j(r_{Mt}-r_{Ft})$$

where

$j \in$ {set of the funds in the model}

T'_j = max {1945, the year when the fund was created}

T''_j = min {1964, the year when and if the fund was cancelled}

Let $\underline{\delta}_j^{TOTAL} = (\alpha_j^{TOTAL},\beta_j^{TOTAL})$, where total means that the regression model includes all the year $T'_j,\ldots,T''_j$.

Let $\underline{\delta}_j^{i} = (\alpha_j^{i},\beta_j^{i})$ be the estimates of α_j and β_j when year i is deleted $i \in \{T'_j,\ldots,T''_j\}$.

We are interested in the quantity $(\underline{\hat{\delta}}_j^{TOTAL} - \underline{\hat{\delta}}_j^{i})$, $\forall j$ and $\forall i$.

Let

$$X = \begin{bmatrix} 1 & r_{MT'_j} - r_{FT'_j} \\ \vdots & \vdots \\ 1 & r_{MT''_j} - r_{FT''_j} \end{bmatrix}$$

and let $H = X(X^TX)^{-1}X^T$.

Then it is not difficult to prove that:

$$\underline{\hat{\delta}}_j^{TOTAL} - \underline{\hat{\delta}}_j^{i} = \frac{(X^TX)^{-1}\underline{X}_i r_i}{1-h_{ii}}$$

where $\underline{X}_i$ denote the i^{th} row of X, r_i the residual $r_{ji} - r_{Fi} - \underline{X}_i \hat{\delta}_j^{TOTAL}$, and h_{ii} is the i^{th} diagonal element of H.

We want also to indicate that it is possible to investigate other perturbation of the data. One can perturb any element of the matrix X or perturb the assumption of homoscedacticity of the various observations (by considering a variance of σ^2/P_i and investigate small changes in P_i).

Because of computer time limitations we concentrated on investigating the quantity $(\underline{\hat{\delta}}_j^{TOTAL} - \underline{\hat{\delta}}_j^{i})$ which seemed to us the most important. We used a macro program that was implemented in the troll system in order to do the actual computations.

The results of the sensitivity analysis appear in Table 4. For each of the funds in our sample of 10 funds the rows (1 and 2) represents the two estimators $(\hat{\alpha},\hat{\beta})$ and the column represents the year deleted. For example, the number -.001589 for fund 168 that appears in Row 1, Column 2 is the difference between the estimate for least squares and the estimate where 1951 is deleted. The most interesting results are the changes of sign of the estimate for α, that occured in

some cases. For fund 168 - Composite Fund, Inc., we see that if we delete the year 1957 our estimate for α would become positive (from -.00369 to .0004136). Also for fund 249 - Television-Electronic Fund, Inc., the estimate for α becomes positive (from -.00824 to .00542) after deleting the year 1951, and (to .00198) after deleting the year 1962. For the rest of the funds there were changes in the magnitudes but a change of sign did not happen.

According to the results summarized in Table 5 we may notice that the removal of 1962 observation reveals a major trend towards more positive intercept term ($\hat{\alpha}^{1962}$). More precisely for 8 out of the 10 funds studied performance improved ($\hat{\alpha}^{1962} - \hat{\alpha}^{LS} > 0$). In case that the 1962 data points are outliers, this would indicate that 80% of the portfolio managers in the sample did better relative to the estimates where 1962 is not regarded as an extraordinary year. It is conceivable that the reduction in performance imposed by 1962 is due to erratic movements in the capital markets in this year.

It is peculiar to 1962 that elimination of its observations reveals opposite movements in the magnitudes of the performance estimate (α) and the volatility coefficient (β) for all the 10 funds. This suggests that 80% of the funds studied became less risky once 1962 is deleted. There is a possibility that portfolio managers made unsuccessful moves into riskier stocks in 1962. In order to test this hypothesis we should proceed into analyzing the dynamic composition of the sample portfolios over a period of time including 1962.

There may be some empirical support for considering classifying 1962 as an outlier. In any case, the peculiarity of this year cannot be neglected in future studies. Table 5 illustrates these remarks.

Even though looking at movements in the performance coefficient

(α) of individual funds is insightful to detect particular trends, in order to be consistent we should look also at averages. The average $\bar{\alpha}_{LS}$ is -.0266. Upon deletion of 1962 the average performance measure $\bar{\alpha}^{1962}$ increased to -.02503.

In order to determine the significance of the change a robust estimate of the standard deviation of α was used as suggested by Breiman [8].

$$\sigma^*_{\hat{\alpha}} = \sqrt{\frac{\pi}{2}} * MAD$$

$$MAD = \sum_{i=1}^{10} \frac{|\hat{\alpha}_{LS_i} - \bar{\hat{\alpha}}_{LS}|}{10}$$

Since $\sigma^*_{\alpha} = .0313$ we are tempted to conclude that the estimate of the average performance of portfolio managers does not improve significantly if 1962 is deleted ($|\bar{\hat{\alpha}}_{LS} - \bar{\hat{\alpha}}^{1962}|/\sigma^*_{\hat{\alpha}_{LS}}$ is small). The average is still negative confirming Jensen's assertion about the inability of portfolio managers in the average to pick "winners". Deleting years 1951, 1956, and 1957 was also relevant for some funds.

JBETA 168

1950-1964

Table 4

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	-0.000408	-0.001589	-0.000393	-0.000724
2	-0.006267	-0.007356	-0.000369	0.00272

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	-0.000484	-0.001153	0.002011	-0.004135
2	0.016032	-0.017147	-0.005033	0.000079

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	6.261286E-07	0.002593	0.004401	0.00071
2	-0.000216	-0.003829	-0.016678	0.004182

ROW	COLUMN 13	COLUMN 14	COLUMN 15
1	-0.001243	-0.00011	0.001263
2	0.005921	-0.000301	-0.000435

JBETA 198

1945-1964

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	0.000301	0.000717	-0.001757	-0.001175
2	0.015815	-0.003398	0.004392	0.003022

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	0.001204	0.000893	-0.000644	-0.00048
2	0.002196	0.01724	-0.003867	-0.000766

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	0.002261	-1.838141E-05	-0.000704	0.006783
2	-0.008908	0.000653	-0.013136	-0.016494

ROW	COLUMN 13	COLUMN 14	COLUMN 15	COLUMN 16
1	-0.003461	2.129217E-05	0.002257	-0.001025
2	0.017855	-0.004658	-0.002807	0.004032

ROW	COLUMN 17	COLUMN 18	COLUMN 19	COLUMN 20
1	-0.003249	-0.002087	-0.000588	0.001561
2	-0.024438	0.010542	-0.002203	0.000309

1954-1964

Table 4 (Cont'd).

JBETA 206

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	-0.000122	-0.001486	-0.001364	-0.003871
2	0.011225	-0.0153	0.002897	0.017671

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	0.000556	-0.001042	0.009086	1.377515E-05
2	0.02797	0.001184	-0.03115	6.699041E-05

ROW	COLUMN 9	COLUMN 10	COLUMN 11
1	0.002743	-0.00404	-0.000755
2	-0.012248	-0.010161	5.716374E-06

JBETA 220

1947-1964

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	-0.001038	-0.000309	0.002604	-0.000476
2	0.002788	0.000852	0.004897	-0.011997

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	0.000164	-0.001433	0.001795	0.000277
2	0.001094	-0.002338	-0.007323	-0.000179

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	-0.000879	0.00167	0.001013	-0.000139
2	-0.021239	-0.00438	-0.005377	0.010277

ROW	COLUMN 13	COLUMN 14	COLUMN 15	COLUMN 16
1	-0.000839	0.0011	0.001108	-0.000571
2	0.001172	-0.004525	0.009456	0.029731

ROW	COLUMN 17	COLUMN 18
1	0.000712	0.001085
2	0.002873	0.000129

1949-1964

218

ETA - DATE REVISED: 9/10/76
PERIODICITY(16) DATA FROM 1 1 TO 2 16

JBETA = MATMULT(DVBETA,HMIDIAG)

1	1	0.000881	-0.001482	-0.001033	2.805846E-05
1	5	0.001085	-0.000459	-0.000317	2.343883E-05
1	9	0.001383	-0.000217	-0.002322	0.002249
1	13	0.001249	-0.001354	-0.000323	0.000546
2	1	0.001076	-0.026773	-0.004994	2.764065E-05
2	5	-0.004248	0.012431	-0.005467	-6.280633E-05
2	9	-0.006897	0.022301	0.003806	-0.008733
2	13	0.008091	0.006603	-0.000915	-0.000169

Table 4 (Cont'd.)

Table 4 (Cont'd.)

1951-1964

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	-0.004705	-0.002679	0.003688	0.001282
2	-0.024531	-0.003762	-0.013712	-0.007174

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	-0.001576	0.001499	-0.017328	0.000461
2	-0.023535	-0.003473	0.085916	-0.137612

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	-0.00059	-0.003211	-0.002962	0.020531
2	0.000703	0.012047	-0.01918	-0.099638

ROW	COLUMN 13	COLUMN 14
1	0.001392	0.003838
2	0.004584	0.000598

JBETA 2 3 6

1945-1964

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	-0.000247	0.002765	-0.002924	-0.001259
2	-0.012939	-0.013106	0.00731	0.003237

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	0.001354	-0.000264	-0.001001	-0.000598
2	0.00247	-0.005093	-0.006004	-0.000955

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	0.001157	-0.000463	-0.00072	0.000293
2	-0.004506	0.016458	-0.01344	-0.000714

ROW	COLUMN 13	COLUMN 14	COLUMN 15	COLUMN 16
1	0.000624	-7.449285E-05	0.001489	0.005982
2	-0.003221	0.016297	-0.001852	-0.023513

ROW	COLUMN 17	COLUMN 18	COLUMN 19	COLUMN 20
1	0.001219	-0.00576	-0.001017	-0.000237
2	0.009167	0.029102	-0.003809	-4.694585E-05

1949-1964

JBETA 249

Table 4 (Cont'd.)

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	-0.002329	-0.000771	-0.013662	0.012742
2	-0.002637	-0.014165	-0.068003	0.018316

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	0.003408	-0.002164	-0.001935	0.003447
2	-0.013259	0.059291	-0.034224	-0.009095

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	0.00177	-0.000356	0.007245	0.001849
2	-0.008783	0.033802	-0.011064	-0.00726

ROW	COLUMN 13	COLUMN 14	COLUMN 15	COLUMN 16
1	-0.001171	-0.009438	-0.00209	-0.001511
2	-0.007518	0.045995	-0.006022	0.000435

1951-1964

JBETA 253

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	0.000651	-0.004738	0.003061	-0.00048
2	0.003393	-0.006653	-0.011382	0.021384

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	-0.001112	0.006482	0.001766	2.789286E-05
2	-0.016611	-0.015018	-0.008756	0.003742

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	0.009234	0.000361	-0.001965	-0.008243
2	-0.011	-0.001356	-0.012725	0.040003

ROW	COLUMN 13	COLUMN 14
1	-0.000717	-0.003006
2	-0.002361	-0.00042

Table 4 (Cont'd.)

JBETA 1191

1951-1964

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1	-0.002753	-0.004585	0.019403	-0.004148
2	-0.01435	-0.006438	-0.072138	0.18497

ROW	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	-0.001992	0.011384	-0.007923	-0.000259
2	-0.029749	-0.026376	0.039283	-0.0724

ROW	COLUMN 9	COLUMN 10	COLUMN 11	COLUMN 12
1	0.007359	0.00722	-0.005247	-0.006915
2	-0.008766	-0.027088	-0.033974	0.0s356

ROW	COLUMN 13	COLUMN 14
1	-0.007002	-0.00131
2	-0.02306	-0.000183

Fund no.	$\hat{\alpha}_{LS}$	$\hat{\alpha}^{1962}$	$\hat{\alpha}^{1962}-\hat{\alpha}_{LS}$	$\hat{\beta}_{LS}$	$\hat{\beta}^{1962}$	$\hat{\beta}^{1962}-\hat{\beta}_{LS}$	Years of Major Change
168	-.00369	-.00245	+.001243	.595	.58909	-.005921	1957,1951,1962
198	-.0610	-.05992	+.002087	1.2754	1.26486	-.010542	1956,1957,1961
206	.01545	.012707	-.002743	.7170	.72925	+.012248	1957,1960,1962
218	-.00398	-.002626	+.001354	.5168	.5102	-.006603	1957,1960,1962
220	-.03370	-.02799	+.00571	.7612	.73147	-.029734	1949,1956,1962
224	-.05281	-.07341	-.020531	1.282	1.38164	+.099638	1951,1957,1962
236	-.00721	-.00576	+.00576	.7024	.6733	-.029102	1947,1960,1962
249	-.00824	.001198	+.009438	1.00809	.96204	-.045995	1951,1952,1962
253	-.02516	-.016917	+.008243	1.0678	1.0278	-.040003	1956,1957,1962
1191	-.08209	-.075175	+.006915	1.395	1.3614	-.03356	1953,1956,1957
AVER.	-.0266	-.02503	+.0016	.932	.923	-.009	

Summary of the Most Important Changes in Sensitivity Analysis

Table 5

5a. Residual analysis

Concerning returns of individual securities there seemed to be considerable evidence that their distribution belongs to a Stable class of distributions which have finite means but infinite variances Fama [10]). However, it is currently accepted that returns are normally distributed but that variances are non-stationary over time.

Least-squares regression will provide maximum-likelihood estimates of the coefficients if the postulated market model for (13) holds. However, an analysis of the residuals plotted in Figure 1 shows some slight evidence that stationarity through time may not hold for all funds. Except for funds 168 and 200, the plots do not indicate a horizontal "band" of residuals. According to Draper & Smith [9] either long-term or short-term time effects might be influencing the data. The fact that the variance might not be constant over time implies that a weighted least squares analysis should have been used. This seems to provide enough support for using robust regression techniques, described below, that iterate to the optimal estimate through weighted least squares steps.

5b. Robust Regression- Summary

Robust Regression is a new technique designed to outperform ordinary least squares when the errors in a regression model have non-Gaussian distributions with longer tails.

Robust regression is intended to meet two conditions of robust or "resistant" techniques

1) the coefficients should not be unduly influenced by any small portion of the data.

Figure 1
Fund 206

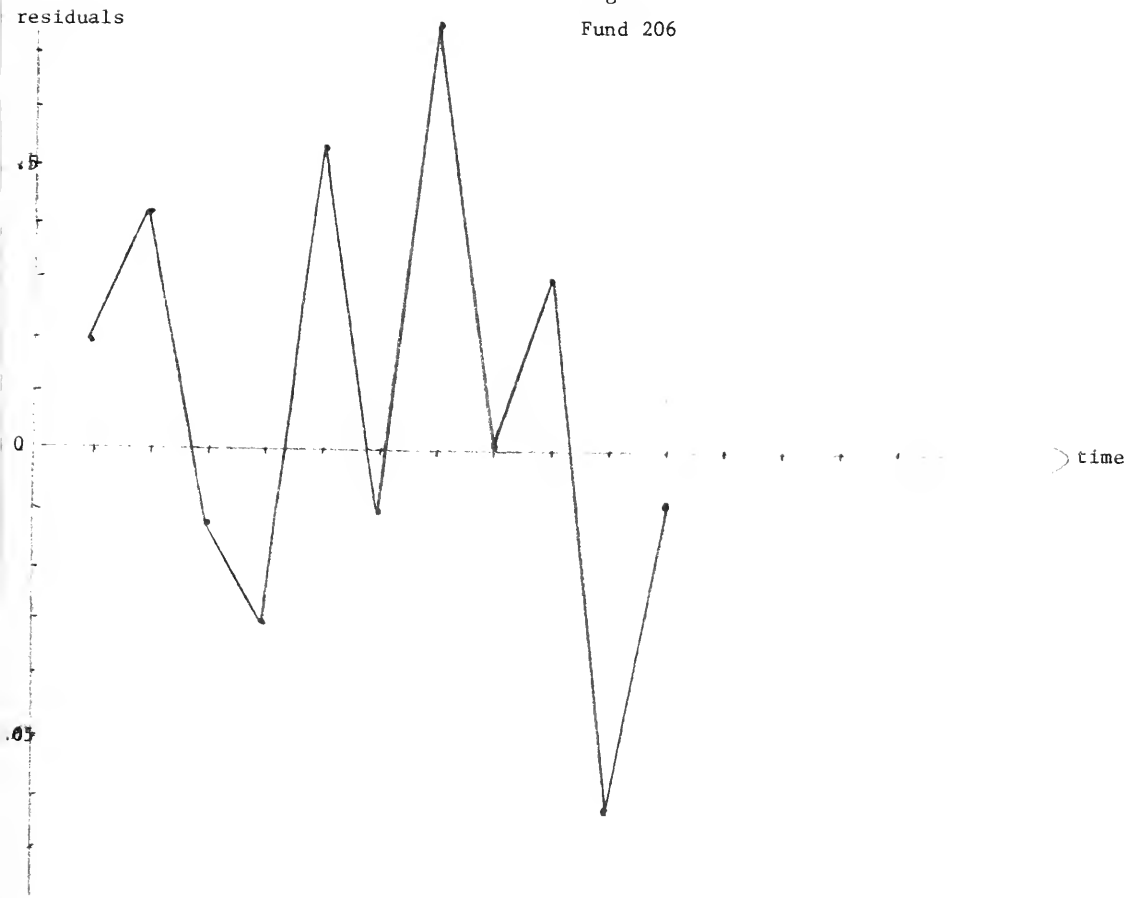

Figure 1
Fund 236

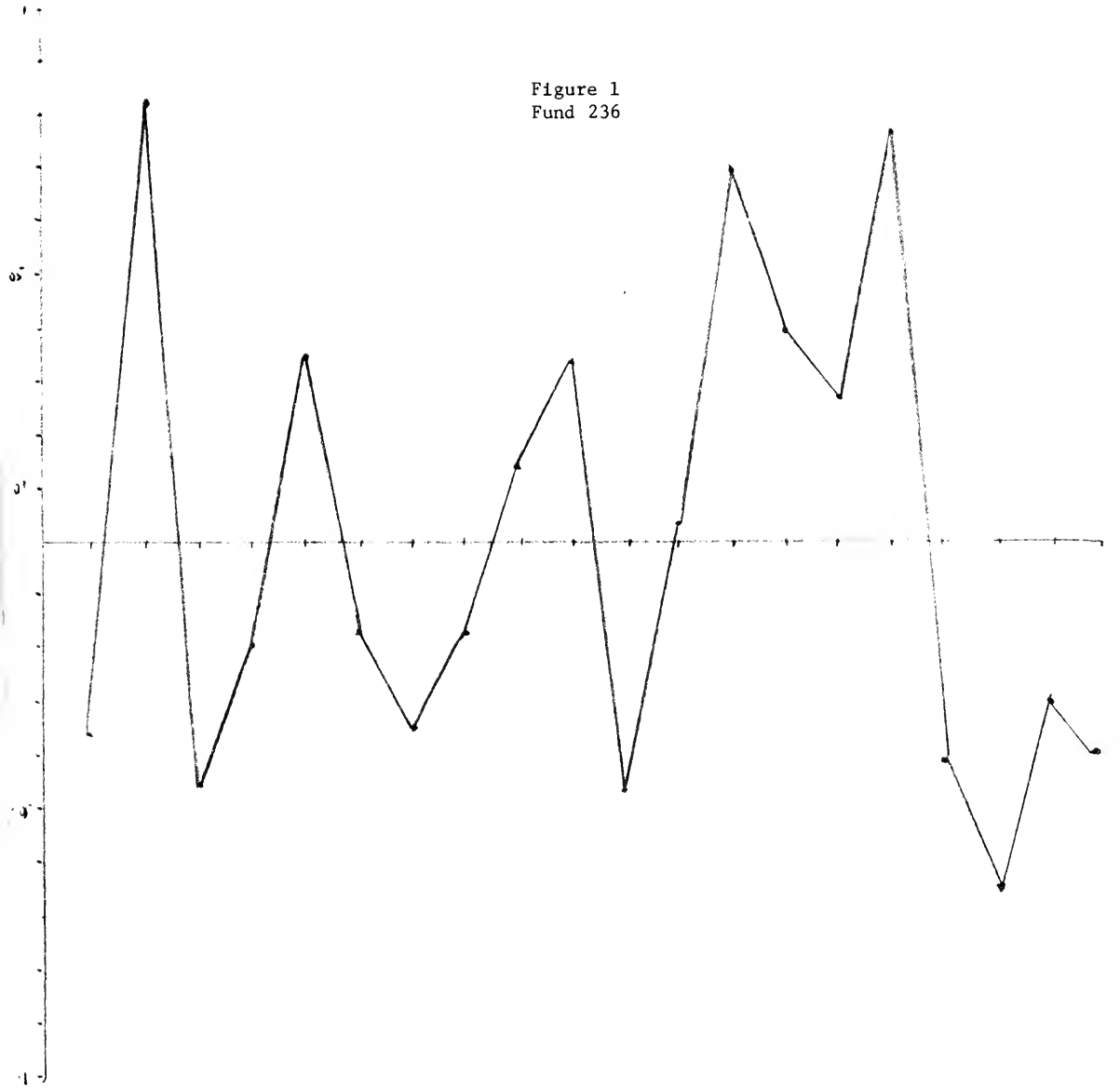

Figure 1
Fund 1198

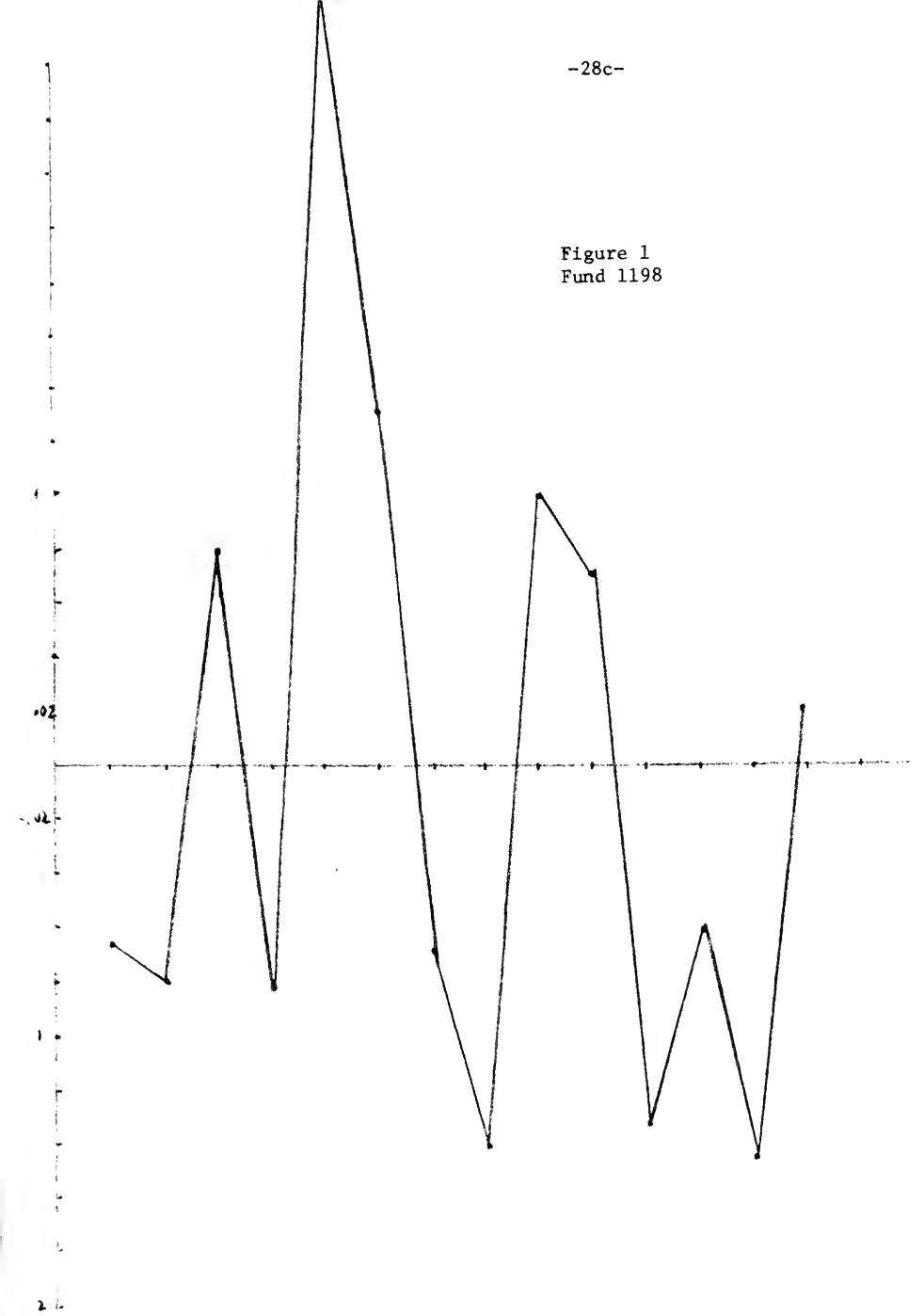

Figure 1
Fund 224

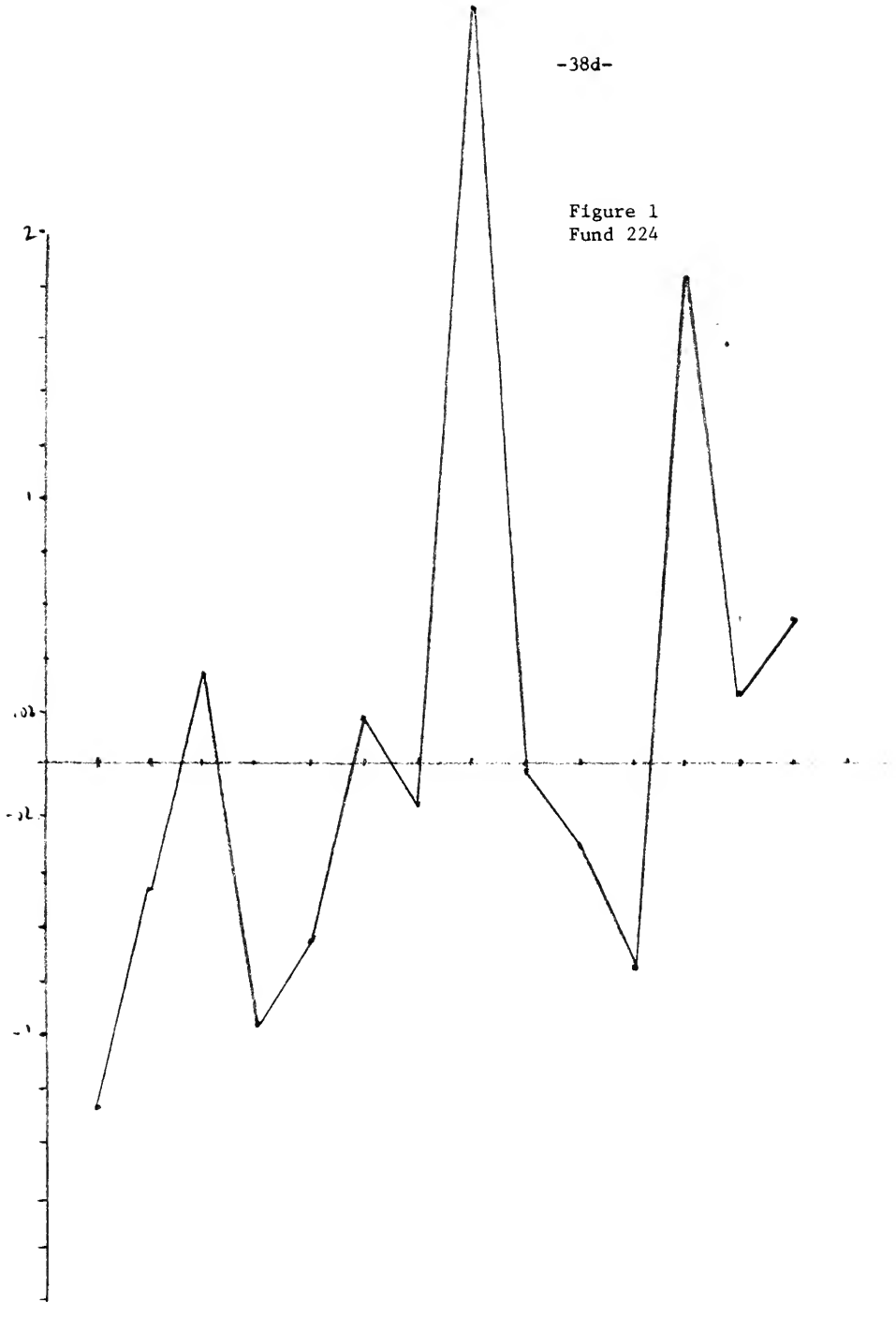

Figure 1
Fund 249

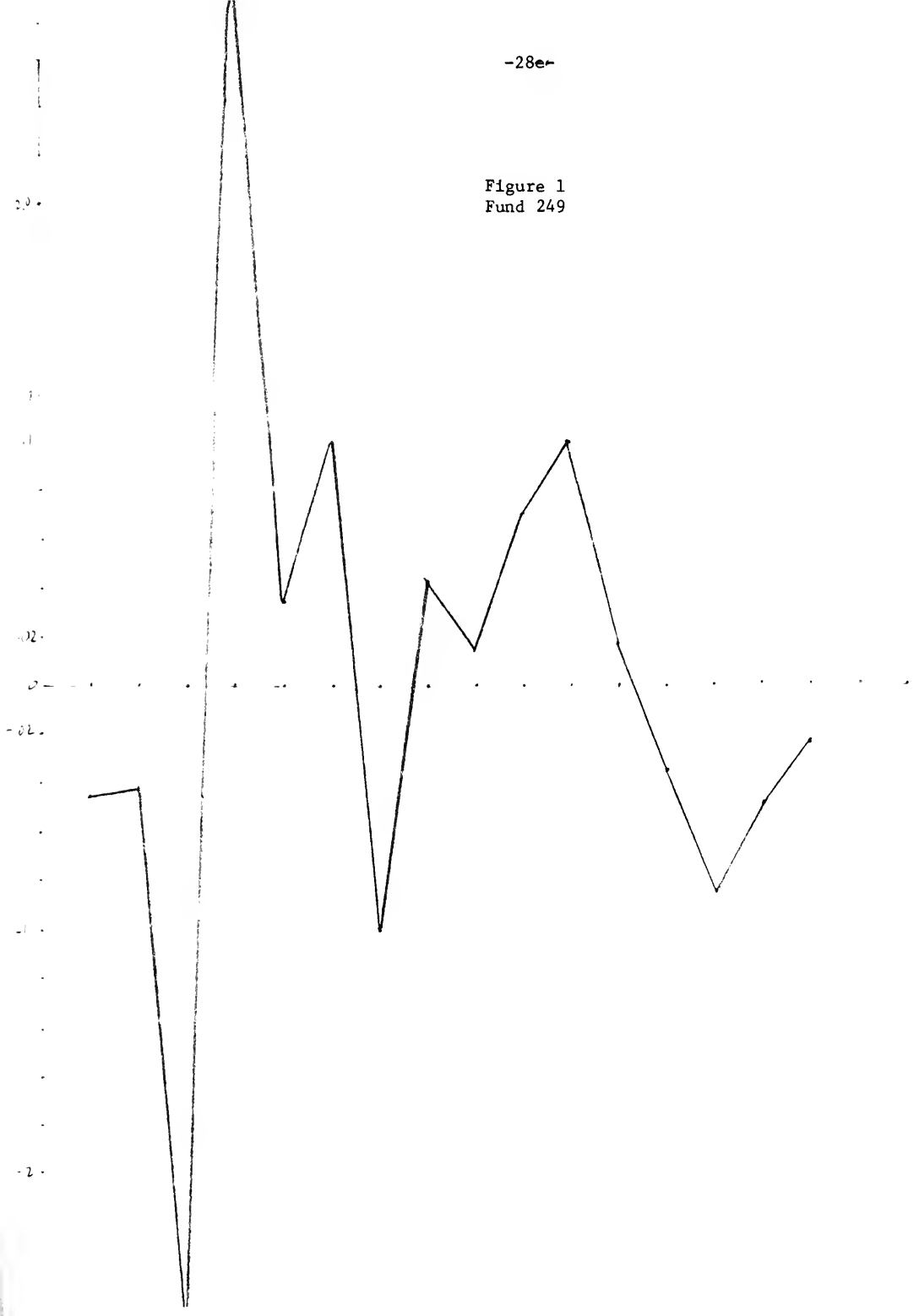

Figure 1
Fund 218

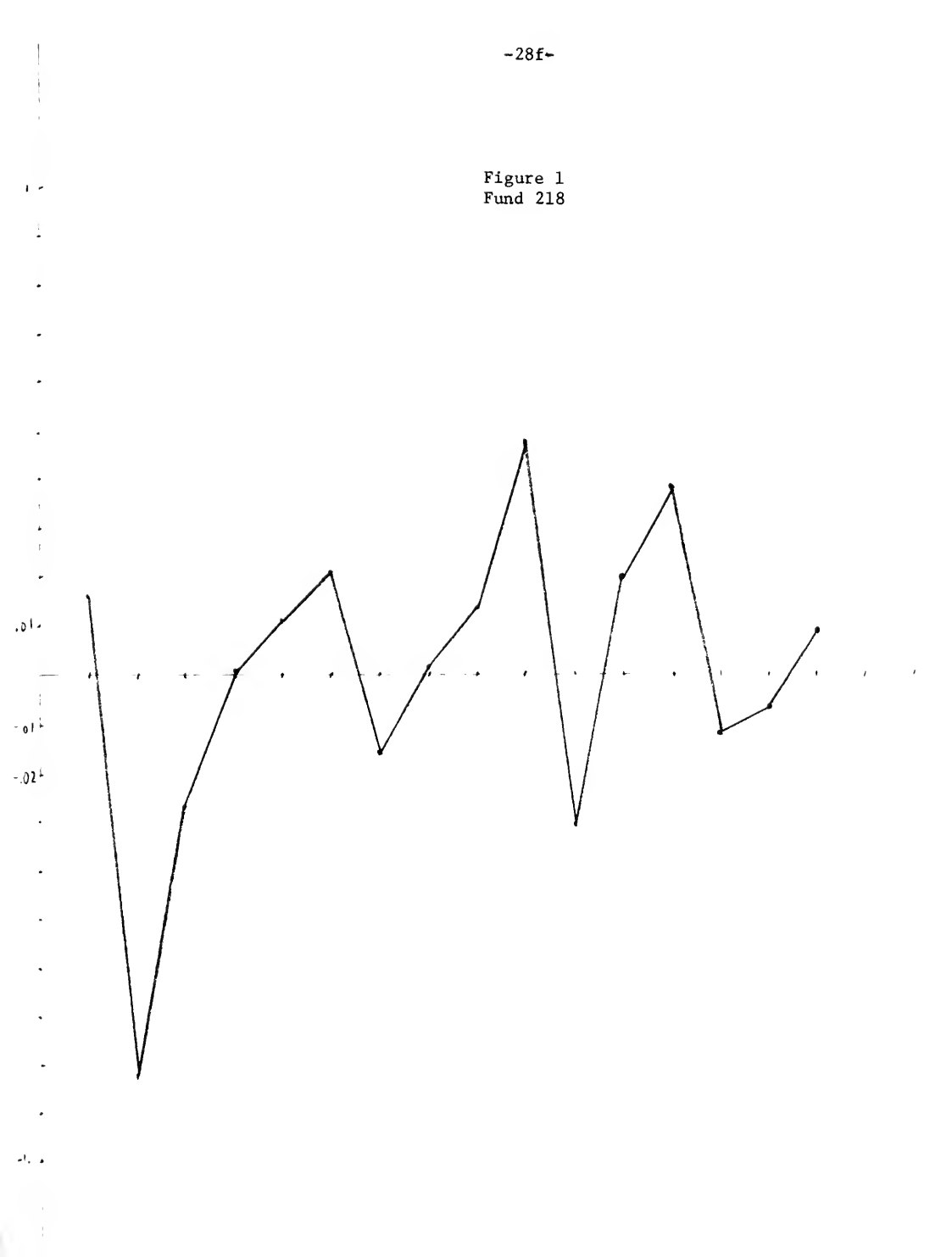

Figure 1
Fund 198

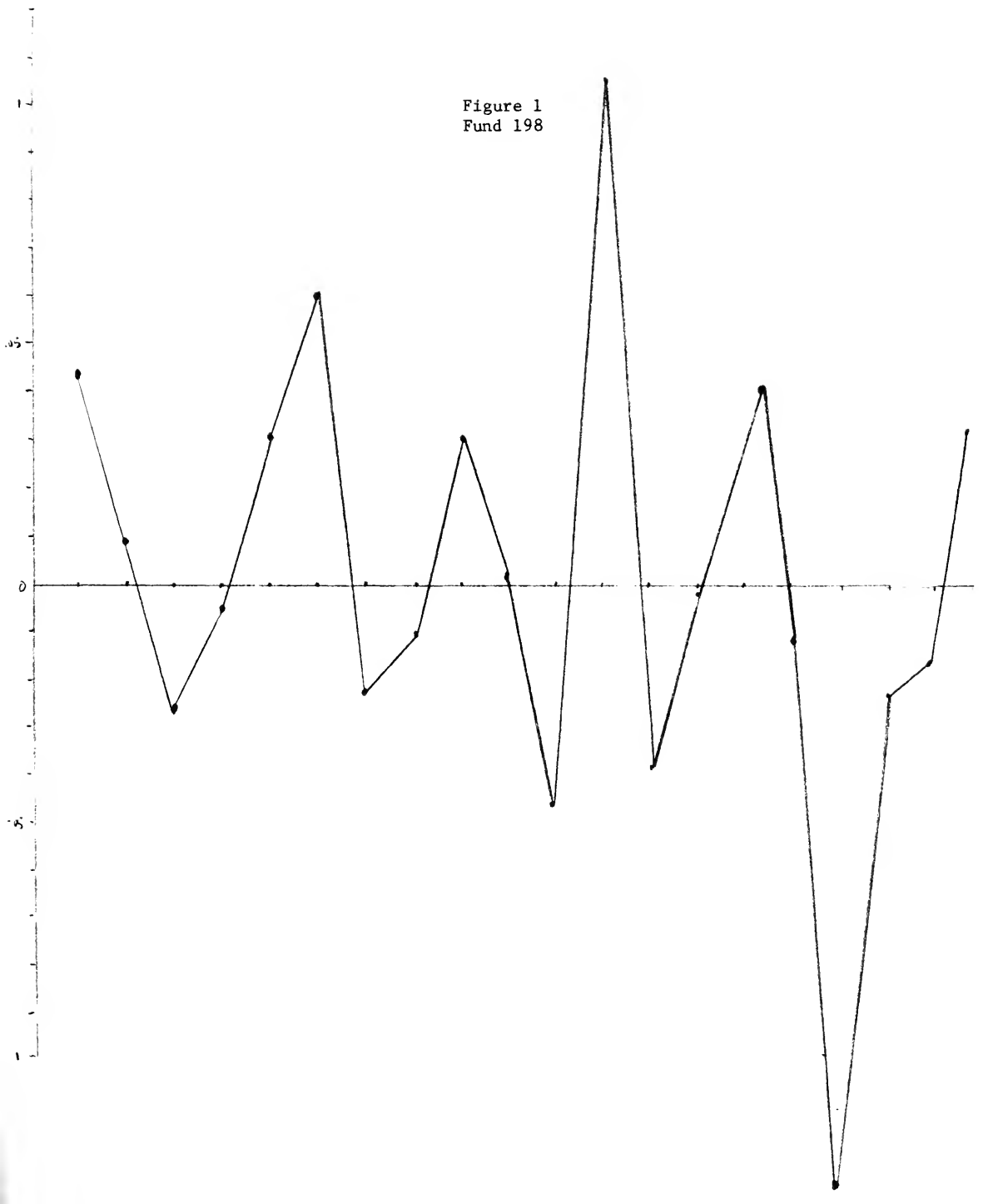

Figure 1
Fund 253

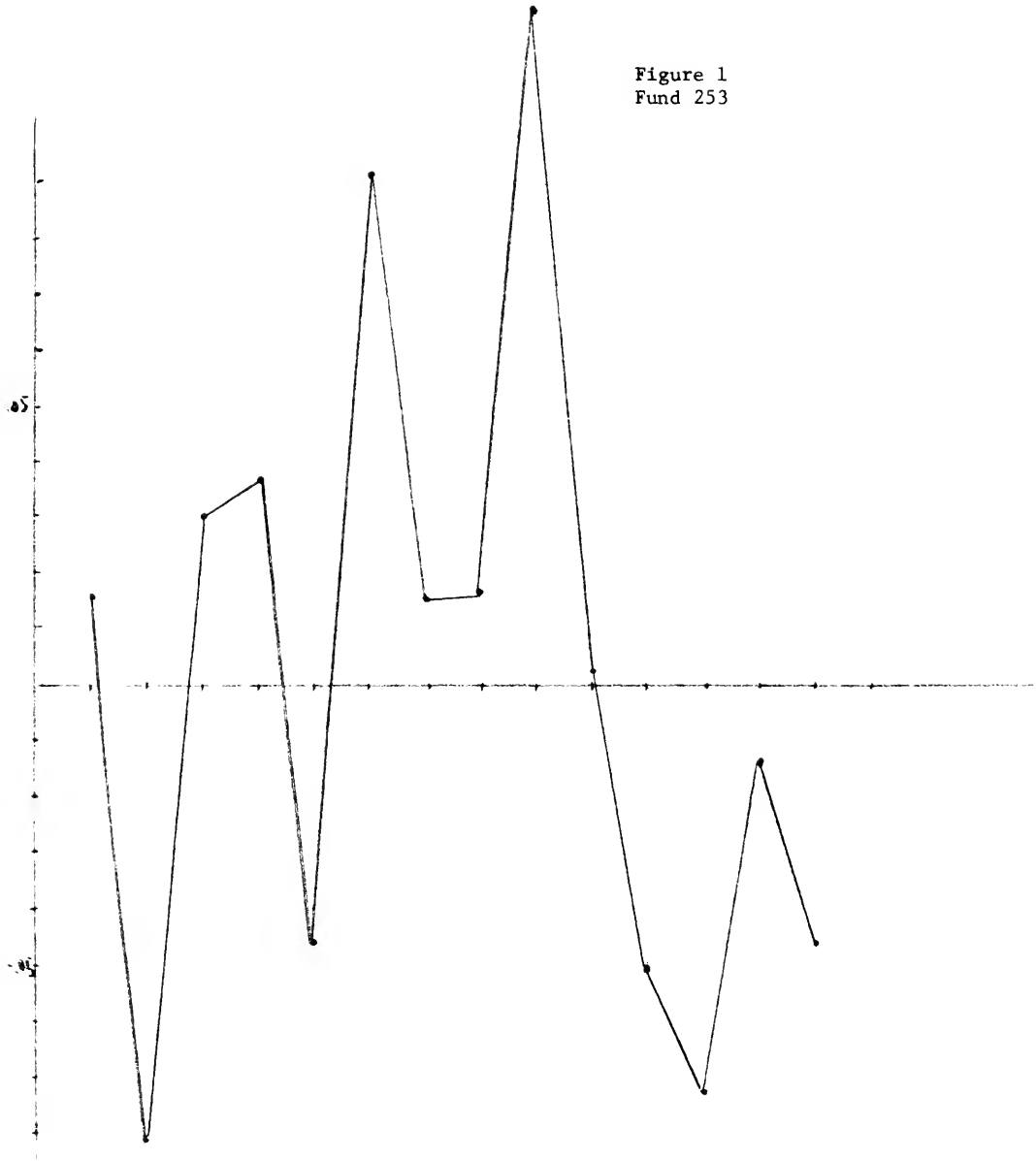

Figure 1
Fund 168

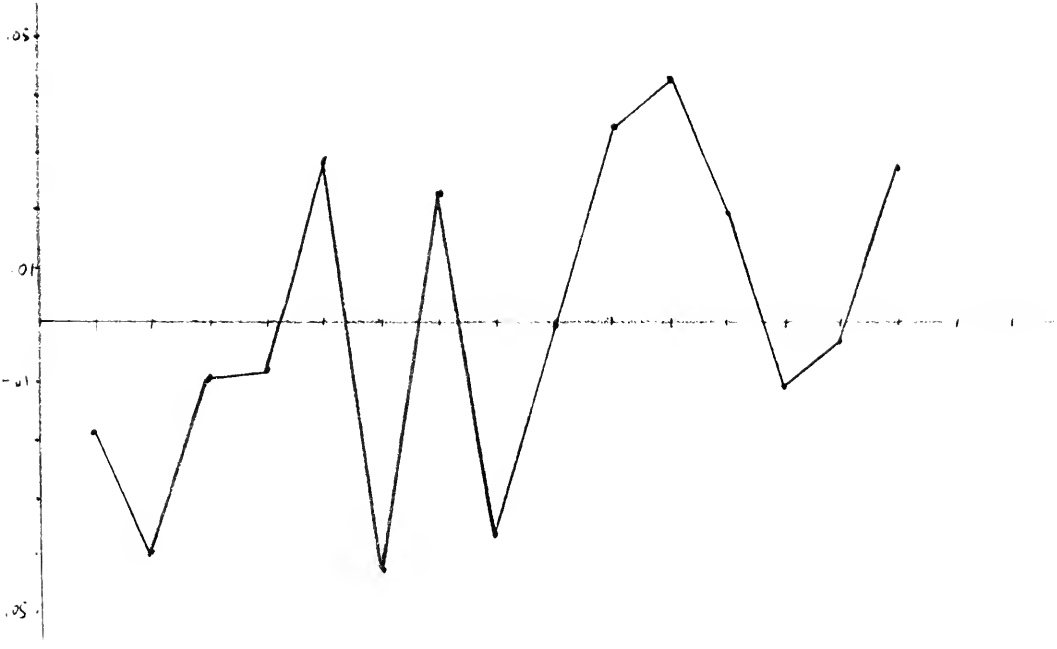

Figure 1
Fund 220

2) minor inaccuracies in the model should cause only minor errors in the final results.

This technique is performed iteratively by means of reweighted least squares.

The method starts with an initial set of coefficients. It then computes the residuals and reweights the data observations, using a technique similar to a minimization of a criterion function. The weights thus obtained are used in computing new coefficients which in turn produce new residuals and a new set of weights.

The user specifies a weighting function in the εRobust macro implemented in the TROLL system used in this work. If we let the data vector $\underline{Y}$ stand for the dependent variable (in the current study $Y = (\tilde{r}_j - r_{Ft})$) and the data matrix X for the dependent variables (in this application, column 1 is filled with 1's and column 2 is $(\tilde{r}_{mt} - r_{ft})$) the fitting of the linear model is accomplished by searching for $\hat{\alpha}$ and $\hat{\beta}$ which minimize

$$\sum_{i=1}^{n} \rho_c\left(\frac{r_{j_i} - r_{FT_i} - \hat{\alpha} - \hat{\beta}(rMT_i - r_{FT_i})}{s}\right)$$

or equivalently

$$\sum_{i=1}^{n} \rho_c\left(\frac{Y_i - X_i\hat{\beta}}{s}\right)$$

where s is a scale estimate and $\rho_c(\cdot)$ is the loss function.

The "robust" macro implemented in TROLL permits specifying three different families of loss functions. Of these only the Huber criterion was used and will be briefly illustrated here. For details see [7]. The Huber loss function was chosen because it is the only convex criterion available and therefore convergence to a global minimum is guaranteed.

$\rho'(\cdot) = \psi_c(x) = \max(-c, \min(c, x))$

The sensitivity and stability of the fit, coefficient estimates and residuals may be examined by varying $\underline{c}$ and plotting the results.

In order to start the process it is necessary to specify an initial guess for the coefficient estimates. The system default choice is to use the coefficient estimates derived from the well known and widely used least absolute residuals (LAR) criterion function ($\rho(t) = |t|$, or $\rho' = \psi_o(x)$).

The LAR method exists also as macro that may be invoked by the user in the TROLL system. It performs linear regression using a linear programming algorithm for minimizing the sum of absolute residuals.

The LAR criterion was thoroughly used in this study as a means of challenging the robustness of the Jensen's capital asset pricing model results and at the same time saving computer time when compared to complete robust regression

A complete robust regression run using Huber loss function was obtained for fund 218. This fund was chosen because its least square α value is nearer the borderline. The results are shown in Table 6 for various values of the constant $\underline{c}$. We may notice that α is positive at c = 0 (LAR) but becomes negative at c = 1 and thereafter. A Huber trace for β is shown in Table 7, which indicates stability of the coefficient β at the various values of $\underline{c}$. The Huber Trace feature available in the TROLL system, unfortunately does not plot the intercept term.

Robust runs are lengthy and expensive and the results for fund 218 suggested that we should proceed with the other 9 funds using only the LAR code which is also the first step in the robust run.

C = 0 SSR = .015154 SAR = .357784
R = 1 MSSR = .000036 MSAR = .02065

NOB = 10 NOVAR = 2 STEP = 4 SCALE = 1
RSQ = .859324 MRSQ = .096233 SER = .032001 MSER = .001599
SR = -.021548 LHSMEAN = .056072 SUMW = 2.12504 RIDGE = 0
F(1/14) = 35.5105 MF(1/14) = 3702.02

COEFS

	BETA	COEF	STD ERR	T STAT
A	0.007047	0.002313	0.001097	2.10905
B	0.854306	0.47467	0.007811	60.7691

	MEAN	PRIOR
A	1.	0.
B	0.117358	0.

C = 1 SSR = .01475 SAR = .353359
R = .5 MSSR = .000948 MSAR = .203399

NOB = 10 NOVAR = 2 STEP = 4 SCALE = 1
RSQ = .863079 MRSQ = .025184 SER = .032459 MSER = .022278
SR = -.057305 LHSMEAN = .056072 SUMW = 13.7266 RIDGE = 0
F(1/14) = 88.2486 MF(1/14) = 175.126
MAXEIG = 14.1551 MINEIG = .860061 COND# = 16.4583

COEFS

	BETA	COEF	STD ERR	T STAT
A	-0.004698	-0.001542	0.005921	0.260395
B	0.948327	0.520872	0.040663	12.957

	MEAN	PRIOR
A	1.	0.
B	0.117358	0.

Table 6 - Robust Regression Results for Fund 218

C = 39 SSR = .014505 SAR = .359379
R = .025 WSSR = .014505 WSAR = .359379

COEFS

	BETA	COEF	PRIOR
A	-0.01213	-0.003681	0.
B	0.930242	0.516825	0.

C = 9 SSR = .014505 SAR = .359379
R = .1 WSSR = .014505 WSAR = .359379

C = 4 SSR = .014505 SAR = .359379
R = .2 WSSR = .014505 WSAR = .359379

C = 2.33333 SSR = .014602 SAR = .358368
R = .3 WSSR = .012024 WSAR = .341831

C = 1.5 SSR = .014714 SAR = .358406
R = .4 WSSR = .00938 WSAR = .31751

Table 6 (Cont'd.)

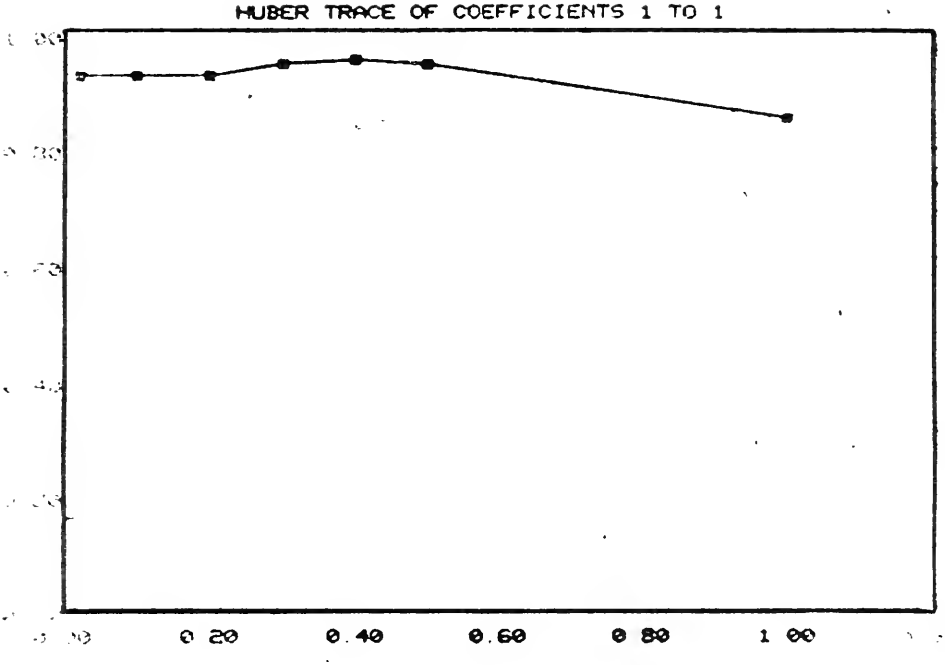

Table 7 - Huber Trace for Fund 218

6. Least Absolute Residuals Regression Results

The results of the LAR regression are shown on Table 8. Results are also summarized in Table 9, where they are compared to the least square regression results. The most important results are the change of sign of the $\hat{\alpha}$ for the two funds 206 and 218. For the fund 206 - "Istel Fund Inc", $\hat{\alpha}$ changed from .01545(the LS) to -.00198 (LAR). For the fund 218 - "Massachusetts Life Fund" we have a corresponding change of $\hat{\alpha}$ from -.00398 to .007047. For the fund 249 - "Television-Electronics Funds, Inc.", we have significant change both in $\hat{\alpha}$ and in $\hat{\beta}$. They changed correspondingly from -.00824 and 1.00809 to -.013519 and .860861. For the rest of the funds we have also changes in the magnitude of $\hat{\alpha}$ and $\hat{\beta}$ although the sign of $\hat{\alpha}$ has not changed. Standard deviation for estimates of α are included in the table for the purpose of evaluating the significance of the distance between the two estimates. In all cases the LAR estimates are within one standard deviation of the LS estimates. We avoided using t statistics because under LAR we don't have the necessary normality assumptions.

Table 9 shows that 5 out of the 10 funds studied moved slightly into poorer performance measure while the other 5 showed slight improved performance. In the average performance is poorer under this criterion. However the reduction in the average performance coefficient is again not significant.

Also the least absolute residuals regression reveals a lower average systematic risk suggesting that the funds seem to be more conservative in their investment policies, offering investors portfolios with smaller systematic risk. The average systematic risk (.905) is in this situation significantly smaller than under least squares (.932) already lower than the market portfolio systematic risk (1.).

LAR REGRESSION RESULTS FOR R168-RFT ON NEWX

NOB = 15 NOVAR = 2
RSQ = 0.909657 MLRSQ = 0.891042 ROBRSQ = 0.702687
SER = 0.030716 MEDAR = 0.025795 SSR = 0.012265 SAR = 0.340007

COEF	ST ER
-0.010121	0.009969
0.618414	0.05195

COVARIANCE MATRIX

9.930861E-05	
-0.000314	0.002699

LAR REGRESSION RESULTS FOR R198-RFT ON NEWX

NOB = 20 NOVAR = 2
RSQ = 0.936541 MLRSQ = 0.950317 ROBRSQ = 0.974095
SER = 0.05165 MEDAR = 0.022609 SSR = 0.048019 SAR = 0.683438

COEF	ST ER
-0.078259	0.014211
1.32339	0.078034

COVARIANCE MATRIX

0.000202	
-0.000646	0.006089

LAR REGRESSION RESULTS FOR R206-RFT ON NEWX

NOB = 11 NOVAR = 2
RSQ = 0.888617 MLRSQ = 0.916569 ROBRSQ = 0.9996
cSER = 0.046137 MEDAR = 0.001566 SSR = 0.019158 SAR = 0.298469

COEF	ST ER
-0.001937	0.016714
0.806601	0.083792

COVARIANCE MATRIX

0.000279	
-0.000776	0.002021

Table 8

Table 8 (Cont'd.)

LAR REGRESSION RESULTS FOR R220-RFT ON NEWX

NOB = 18 NOVAR = 2
RSQ = 0.917204 MLRSQ = 0.926489 ROBRSQ = 0.94661
SER = 0.034419 MEDAR = 0.017164 SSR = 0.018954 SAR = 0.45275

COEF	ST ER
-0.025617	0.010188
0.747295	0.057067

COVARIANCE MATRIX

0.000104	
-0.000352	0.003257

LAR REGRESSION RESULTS FOR R224-RFT ON NEWX

NOB = 14 NOVAR = 2
RSQ = 0.715 MLRSQ = 0.777596 ROBRSQ = 0.838219
SER = 0.130662 MEDAR = 0.045695 SSR = 0.204872 SAR = 1.04724

COEF	ST ER
-0.039042	0.042568
0.993832	0.226806

COVARIANCE MATRIX

0.001809	
-0.005509	0.051441

LAR REGRESSION RESULTS FOR R236-RFT ON NEWX

NOB = 20 NOVAR = 2
RSQ = 0.882418 MLRSQ = 0.868259 ROBRSQ = 0.878495
SER = 0.039869 MEDAR = 0.026782 SSR = 0.028611 SAR = 0.612753

COEF	ST ER
-0.007049	0.010969
0.654843	0.060234

COVARIANCE MATRIX

0.00012

Table 8 (Cont'd.)

LAR REGRESSION RESULTS FOR R249-RFT ON NEWX

NOB = 16 NOVAR = 2
RSQ = 0.490649 MLRSQ = 0.660068 ROBRSQ = 0.832663
SER = 0.158785 MEDAR = 0.042667 SSR = 0.352978 SAR = 1.45994

COEF	ST ER
-0.013519	0.050735
0.860861	0.268357

COVARIANCE MATRIX

0.002574	
-0.008479	0.072016

LAR REGRESSION RESULTS FOR R253-RFT ON NEWX

NOB = 14 NOVAR = 2
RSQ = 0.894869 MLRSQ = 0.896855 ROBRSQ = 0.733593
SER = 0.06075 MEDAR = 0.04061 SSR = 0.044286 SAR = 0.616769

COEF	ST ER
-0.020154	0.019777
1.10375	0.10545

COVARIANCE MATRIX

0.000391	
-0.001191	0.01112

LAR REGRESSION RESULTS FOR R1191-RFT ON NEWX

NOB = 14 NOVAR = 2
RSQ = 0.656597 MLRSQ = 0.576796 ROBRSQ = -0.552044
SER = 0.160501 MEDAR = 0.076523 SSR = 0.309128 SAR = 1.41404

COEF	ST ER
-0.092227	0.052252
1.09521	0.278601

COVARIANCE MATRIX

0.00273	
-0.008313	

FUND	$\hat{\alpha}_{LAR}$	$\hat{\alpha}_{LS}$	$\hat{\alpha}_{LAR}-\hat{\alpha}_{LS}$	$\sigma(\hat{\alpha}_{LS})$	$\sigma(\hat{\alpha}_{LAR})$	$\hat{\beta}_{LAR}$	$\hat{\beta}_{LS}$	$\hat{\beta}_{LAR}-\hat{\beta}_{LS}$
168	-.01021	-.00396	-.00625	.00982	.00996	.61841	.59524	.0231
198	-.07825	-.06101	-.01724	.01361	.01421	1.3233	1.2754	.0479
206	-.00198	.01545	-.01743	.01532	.01671	.80660	.71908	.0875
218	.00704	-.00398	.0110	.01028	.00231	.85436	.51682	.3375
220	-.02561	-.03370	.008	.00996	.01018	.74729	.76129	-.01399
224	-.03904	-.05281	.0137	.03911	.04253	.99383	1.2822	-.2884
236	-.00704	-.00721	.0016	.01068	.01096	.65484	.70248	-.0476
249	-.01351	-.00824	-.0052	.04959	.05073	.86086	1.0080	-.1394
253	-.02015	-.02516	.0050	.01943	.01977	1.1037	1.0678	.0358
1191	-.09222	-.08209	-.0101	.04739	.05225	1.0952	1.3950	-.2998
AVERAGE	-.0280	-.0266	-.0014			:905	.932	.027

Comparison of LAR and LS Results

Table 9

7. Conclusions

In estimating the performance of portfolio managers (α) and the systematic risk (β), a sample of ten randomly open-ended mutual funds was chosen. The sensitivity analysis indicates that two funds (168 and 249) were sensitive enough to show superior forecasting capabilities of its managers under deletion of yearly observations as compared to inferior performance when the whole set of data is used. However, the years showing considerable effect to change the sign of the estimate α were not the same for these funds.

In a particular analysis of each individual fund it was found that some years provoke major deviations from the estimates based on considering the complete database. One such year that seems to bias the results is 1962. Deletion of these observations implies major magnitude changes for all 10 funds. Also 80% of the funds indicate better performance of its managers forecasting capabilities. For all 10 funds, whenever the performance estimate improved, the systematic risk decreased and vice-versa. This suggests further research should be undertaken in the composition of these funds during this period. In the average portfolio, managers show better performance but not significantly better, under deletion of 1962.

An analysis of the residuals for the complete set of observations in 8 out of 10 funds suggested some time effects in the variances. Robust regression techniques seem to be appropriate to deal with these circumstances.

The robust technique used was Least Absolute Residuals. Two funds (206 and 218) revealed different signs for the performance of portfolio managers and compared to least square estimates. In terms of the average performance, it becomes poorer but again not significantly. The system-

atic risk decreased significantly in the average indicating more conservative portfolios than under the least squares assumptions.

Figure 2 summarizes the effects of both techniques. Riskier stocks show lower performance coefficients under all techniques. Higher β funds seem to be more sensitive to the introduction of least absolute residuals regression than lower β funds.

Our results about average poor performance of portfolio managers do not suggest major departures from Jensen's conclusions. Individually, however, 4 out of the 10 funds studied showed opposite performance to what was estimated by Jensen. (Three funds show better performance, one shows poorer performance leaving with a net better performance in two funds.) At least at the individual fund level, this result suggests that one should be careful when evaluating the strength of results derived uniquely on the basis of least squares regression. In [2] page 415, Jensen concludes "the evidence on mutual fund performance discussed above indicates not only that these 115 mutual funds were on average not able to predict security prices, well enough to outperform a buy-the-market-and hold policy, but also that there is very little evidence that any individual fund was able to do so significantly better than that which we expected from mere random choice."

Our results do not seem to improve the significance of the α's. However, we have to realize that our sample is relatively small; the number of observations were for each fund in the range of 15 to 20 yearly data, and only one special loss function was used (LAR). For comparative purposes it would also be interesting to have a code for performing sensitivity analysis for robust regression runs.

Even though the concentration of this work was in illustrating the application of new statistical techniques in joint tests of the capital asset pricing model, and portfolio managerial performance. These powerful techniques can be very useful also in obtaining more stable estimates of the systematic risk of the portfolios (β). Both Jensen's results [2] and our preliminary findings do suggest that the β's are far more important determinants of portfolio returns. A much more complete work with an enlarged sample would provide us with stronger conclusions about the significance of performance coefficients α's (individuals and average). While the estimation of the β's were not the primary motivation of this initial work we suspect that robust techniques and sensitivity analysis would be also rewarding in refining the estimates of the systematic risk. The latter seems to be the current trend in research in portfolio performance.

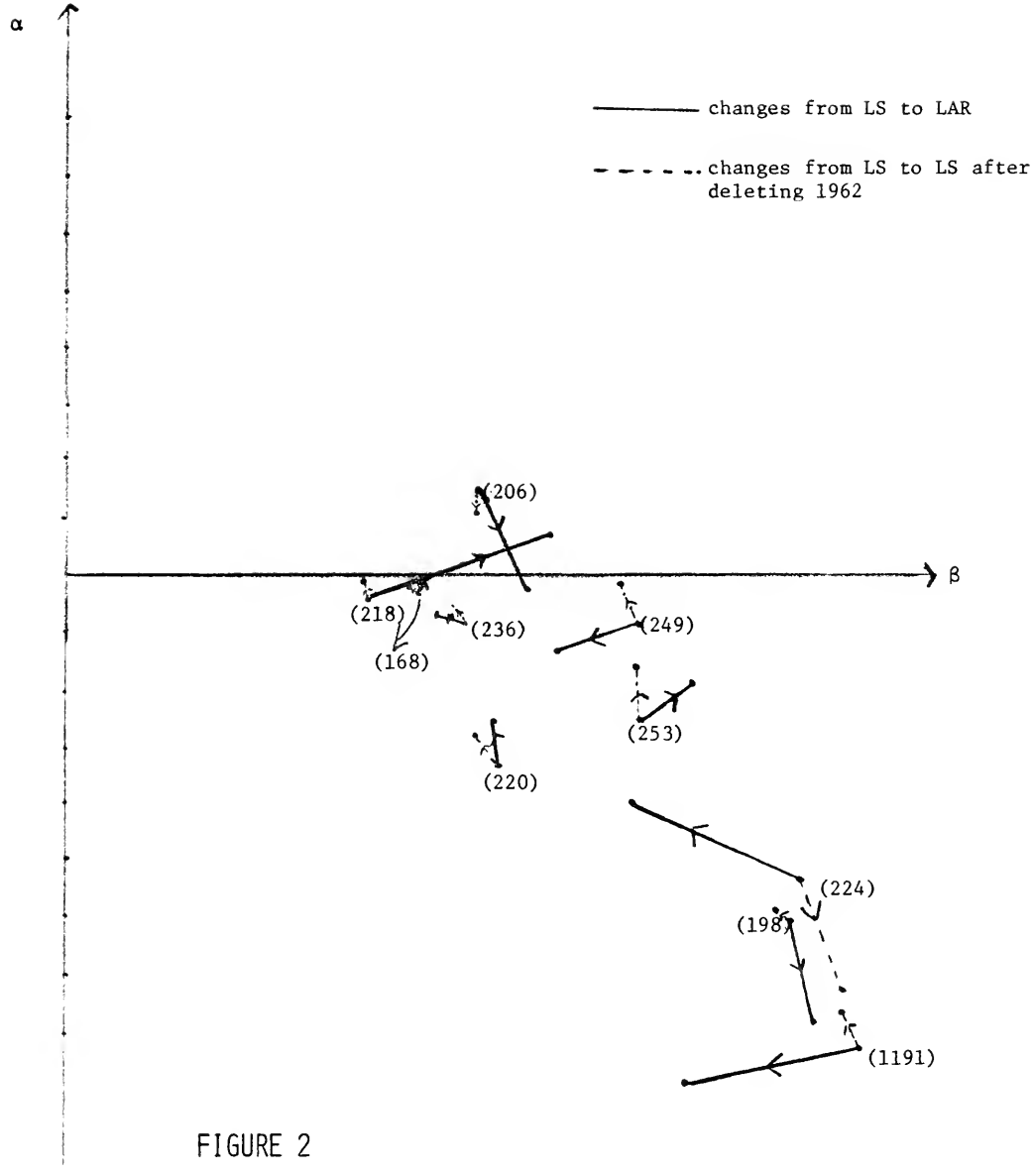
α
β
changes from LS to LAR
changes from LS to LS after deleting 1962
(206)
(218)
(168)
(236)
(249)
(253)
(220)
(224)
(198)
(1191)

FIGURE 2

Attachment A

NAV168 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1949 TO 1964

NAV168 = NAV168/2

1949	5.605	6.16	6.33	A.6
1953	6.18	7.79	8.23	8.15
1957	6.84	7.94	8.32	8.25
1961	9.16	8.07	8.65	9.19

DIV168 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1950 TO 1964

1950	0.155	0.235	0.2	0.2
1954	0.185	0.195	0.18	0.195
1958	0.2	0.2	0.21	0.21
1962	0.21	0.21	0.22	

CG168 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1950 TO 1964

CG168 = CG

1950	0.16	0.18	0.175	0.175
1954	0.215	0.30655	0.47	0.4
1958	0.375	0.375	0.367	0.4
1962	0.4	0.33	0.44	

R168 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1950 TO 1964

R168 = LOG((NAV168+DIV168+CG168)/NAV168(-1))

1950	0.144289	0.090724	0.097032	-0.006842
1954	0.281595	0.114101	0.068101	-0.093046
1958	0.219041	0.113575	0.056884	0.17153
1962	-0.053825	0.129962	0.129912	

NAV198 - DATE REVISED: 9/16/76
c2 ANNUAL DATA FROM 1944 TO 1964

NAV198 = NAV198/6

1944	3.95167	5.07333	3.965	3.62833
1948	3.33667	3.74	4.83	5.36
1952	5.69	5.18	7.87	9.53
1956	9.9	7.01	9.69	10.11
1960	8.41	8.84	6.75	7.39
1964	7.79			

DIV198 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1945 TO 1964

DIV198 = DIV198/6

1945	0.128333	0.141667	0.191667	0.225
1949	0.22	0.238333	0.24	0.22
1953	0.21	0.22	0.24	0.26
1957	0.25	0.19	0.18	0.18
1961	0.16	0.16	0.16	0.16

CG198 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1945 TO 1964

CG198 = CG198/6

1945	0.5	0.208333	0.041667	0.
1949	0.	0.15	0.17	0.18
1953	0.	0.12	0.13	0.56
1957	0.45	0.27	0.57	0.7
1961	0.33	0.23	0.45	0.67

R198 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1945 TO 1964

R198 = LOG((NAV198+DIV198+CG198)/NAV198(-1))

1945	0.36662	-0.161901	-0.026407	-0.018545
1949	0.171271	0.333091	0.177825	0.122683
1953	-0.054165	0.460547	0.229476	0.117666
1957	-0.250017	0.370135	0.113992	-0.084587
1961	0.103813	-0.213574	0.169898	0.159956

NAV206 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1953 TO 1964

NAV206 = NAV203*2

1953	21.09	28.03	31.1	30.71	
1957	25.76	33.33	31.92	34.98	
1961	38.9	33.72	36.08	32.56	

DIV206 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1954 TO 1964

DIV206 = NEWPER(DIV203,1,1954)

1954	0.85	1.1	1.3	1.3	
1958	1.13	1.13	0.4	1.23	
1962	1.13	1.18	1.22		

CG206 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1954 TO 1964

CG206 = CG203

1954	0.7	1.2	0.86	1.15	
1958	1.4	3.65	0.	2.41	
1962	3.35	0.33	2.15		

R206 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1954 TO 1964

R206 = LOG((NAV206+DIV206+CG206)/NAV206(-1))

1954	0.338298	0.17528	0.055351	-0.084913
1958	0.330799	0.096317	0.102913	0.195668
1962	-0.018159	0.108646	0.126123	

Attachment A (Cont'd.)

NAV - DATE REVISED: 9/03/76
ANNUAL DATA FROM 1948 TO 1964

1948	6.25	6.69	6.77	7.00
1952	7.385	7.155	8.75	9.58
1956	9.5	8.785	10.715	10.65
1960	10.53	11.98	10.92	11.65
1964	12.31			

DT = DT(2)

1948	0.	0.247	0.256	0.263
1952	0.261	0.265	0.282	0.3
1956	0.31	0.333	0.34	0.345
1960	0.355	0.35	0.35	0.35
1964	0.36			

CGT - DATE REVISED: 9/03/76
ANNUAL DATA FROM 1949 TO 1964

1949	0.0312	0.09125	0.12575	0.0464
1953	0.075	0.1	0.1175	0.175
1957	0.08	0.135	0.175	0.14
1961	0.21	0.18	0.22	0.24

R218 = LOG((NAV+DT+CGT)/NAV(-1))

1949	0.108775	0.061907	0.05881	0.093606
1953	0.014785	0.243973	0.131729	0.018
1957	-0.032306	0.241974	0.041586	0.08226
1961	0.174695	-0.045249	0.112478	0.102696

Attachment A (Cont'd)

NAV22000 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1946 TO 1964

1946	7.19	6.9	6.47	7.19
1950	7.61	8.08	8.07	7.53
1954	9.35	9.83	9.56	8.09
1958	9.98	9.91	9.3	10.22
1962	8.8	9.71	10.26	

DIV220 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1947 TO 1964

1947	0.275	0.2575	0.2855	0.2284
1951	0.222	0.2065	0.2355	0.26
1955	0.27	0.333	0.293	0.323
1959	0.3	0.3	0.3	0.27
1963	0.25	0.25		

CG220 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1947 TO 1964

1947	0.	0.2285	0.0895	0.4216
1951	0.428	0.3435	0.1795	0.29
1955	0.38	0.377	0.267	0.237
1959	0.26	0.21	0.3	0.14
1963	0.26	0.35		

R220 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1947 TO 1964

R220 = LOG((NAV22000+DIV220+CG220)/NAV22000(-1))

1947	-0.002088	0.008083	0.156356	0.138733
1951	0.137301	0.064692	-0.015611	0.273639
1955	0.114092	0.043788	-0.100029	0.264548
1959	0.047931	-0.010142	0.196556	-0.151821
1963	0.149594	0.111929		

Attachment A (Cont'd.)

NAV224 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1950 TO 1964

1950	3.81	3.89	3.83	3.26
1954	4.42	5.08	4.69	2.71
1958	4.06	4.1	3.43	3.79
1962	3.56	4.28	4.85	

DIV224 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1951 TO 1964

1951	0.308	0.298	0.271	0.22
1955	0.297	0.299	0.269	0.21
1959	0.21	0.2	0.2	0.19
1963	0.18	0.2		

CG224 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1951 TO 1964

1951	0.	0.18	0.15	0.04
1955	0.13	0.28	0.3	1.
1959	0.06	0.1	0.04	0.04
1963	0.	0.1		

R224 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1951 TO 1964

R224 = LOG((NAV224+DIV224+CG224)/NAV224(-1))

1951	0.096978	0.102064	-0.03968	0.372197
1955	0.21988	0.036528	-0.35795	0.865081
1959	0.073579	-0.09459	0.161206	0.
1963	0.225388	0.185044		

Attachment A (Cont'd.)

NAV236 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1944 TO 1965

NAV236 = NAV236/2

1944	7.385	8.42	7.81	7.64
1948	7.07	7.805	8.79	9.21
1952	9.56	9.01	11.79	12.75
1956	12.44	10.85	13.64	14.5
1960	14.57	17.05	14.44	15.51
1964	16.03	7.5		

DIV236 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1945 TO 1964

DIV236 = DIV236/2

1945	0.22	0.265	0.34	0.32
1949	0.345	0.395	0.375	0.375
1953	0.375	0.375	0.4	0.42
1957	0.43	0.42	0.42	0.43
1961	0.43	0.43	0.435	0.45

CG236 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1945 TO 1964

CG236 = CG236/2

1945	0.18	0.135	0.09	0.08
1949	0.055	0.055	0.25	0.25
1953	0.25	0.3	0.45	0.53
1957	0.34	0.44	0.52	0.55
1961	0.62	0.17	0.48	0.54

R236 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1945 TO 1964

R236 = LOG(R236)

1945	0.17757	-0.025257	-0.009003	0.017558
1949	0.148883	0.168777	0.112333	0.190820
1953	0.007314	0.324589	0.142818	0.340723
1957	-0.068189	0.289063	0.110910	0.0838
1961	0.216046	-0.125457	0.110551	0.195682

Attachment A (Cont'd.)

NAV249 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1948 TO 1964

NAV249 = NAV249/4

1948	2.4	2.585	2.96	2.23
1952	3.6	3.4	5.31	5.78
1956	5.9	4.86	7.	8.13
1960	7.73	8.87	6.96	7.62
1964	8.11			

DIV249 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1949 TO 1964

DIV249 = DIV249/4

1949	0.07155	0.1378	0.1478	0.1524
1953	0.1451	0.16	0.1732	0.183
1957	0.18	0.1638	0.1625	0.17
1961	0.15	0.14	0.15	0.17

CG249 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1949 TO 1964

CG249 = CG249/4

1949	0.02595	0.1122	0.1147	0.0564
1953	0.1049	0.215	0.2561	0.279
1957	0.276	0.225	0.3125	0.32
1961	0.36	0.26	0.3	0.33

R249 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1949 TO 1964

R249 = LOG(R249)

1949	0.111279	0.216545	-0.171904	0.550047
1953	0.013793	0.514055	0.156536	0.095439
1957	-0.104231	0.418926	0.206433	0.011008
1961	0.19347	-0.186615	0.147973	0.122148

Attachment A (Cont'd.)

NAV253 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1950 TO 1964

NAV253 = NAV253/2

1950	2.61	3.065	3.105	2.91
1954	4.405	5.2	5.5	4.5
1958	6.195	7.38	6.9	7.89
1962	6.2	7.12	7.47	

DIV253 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1951 TO 1964

DIV253 = DIV253/2

1951	0.1	0.105	0.09	0.1
1955	0.15	0.14	0.12	0.11
1959	0.1	0.13	0.11	0.08
1963	0.1	0.1		

CG253 - DATE REVISED: 9/15/76
ANNUAL DATA FROM 1951 TO 1964

CG253 = CG253/2

1951	0.065	0.06	0.075	0.065
1955	0.11	0.19	0.21	0.19
1959	0.2	0.18	0.2	0.18
1963	0.16	0.2		

R253 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1951 TO 1964

R253 = LOG(R253)

1951	0.213131	0.064741	-0.000709	0.45136
1955	0.214708	0.114357	-0.129902	0.380955
1959	0.214876	-0.023305	0.172612	-0.199067
1963	0.174224	0.087362		

Attachment A (Cont'd.)

NAV1191 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1950 TO 1964

1950	3.72	4.07	4.09	4.21
1954	9.	10.28	10.35	7.54
1958	9.43	9.31	8.8	9.
1962	6.66	6.678	6.96	

DIV1191 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1951 TO 1964

1951	0.19	0.18	0.22	0.27
1955	0.33	0.33	0.28	0.28
1959	0.23	0.14	0.07	0.085
1963	0.065	0.085		

CG1191 - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1951 TO 1964

1951	0.	0.03	0.	0.11
1955	0.39	0.47	0.06	0.04
1959	1.5	0.12	0.6	0.
1963	0.2	0.28		

R1191 = LOG((NAV1191+DIV1191+CG1191)/NAV1191(-1))

1951	0.135545	0.0549/2	0.079854	0.801117
1955	0.20067	0.125106	-0.319837	0.257045
1959	0.157629	-0.02722	0.094276	-0.288413
1963	0.041614	0.092474		

Attachment A (Cont'd.)

S - DATE REVISED: 9/03/76
ANNUAL DATA FROM 1944 TO 1964

1944	13.28	12.36	15.3	15.3
1948	15.2	16.76	20.41	23.77
1952	26.57	24.81	35.28	45.18
1956	46.67	39.99	55.21	59.99
1960	58.11	71.55	63.1	75.02
1964	84.75			

D - DATE REVISED: 9/03/76
ANNUAL DATA FROM 1945 TO 1964

1945	0.66	0.71	0.84	0.93
1949	1.14	1.42	1.41	1.41
1953	1.45	1.54	1.64	1.74
1957	1.79	1.75	1.86	1.95
1961	2.02	2.13	2.28	2.5

RMT - DATE REVISED: 9/03/76
ANNUAL DATA FROM 1945 TO 1964

RMT = LOG((SID)/S(-1))

1945	0.305222	-0.080956	0.053447	0.05
1949	0.163504	0.266577	0.210025	0.16
1953	-0.011736	0.413627	0.269754	0.2
1957	-0.110684	0.353719	0.113082	0.08
1961	0.235899	-0.092477	0.202973	0.15

Attachment A (Cont'd.)

R - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1945 TO 1964

1945	2.44	2.21	2.21	2.45
1949	2.42	2.2	2.39	2.74
1953	2.8	2.69	2.68	2.88
1957	3.34	3.24	3.91	4.37
1961	3.89	4.08	3.89	4.15

RFT - DATE REVISED: 9/16/76
ANNUAL DATA FROM 1945 TO 1964

RFT = LOG(1+R/100)

1945	0.024107	0.021859	0.021859	0.023705
1949	0.023911	0.021761	0.023618	0.027093
1953	0.027615	0.026544	0.026446	0.028417
1957	0.032854	0.031885	0.038355	0.042771
1961	0.038162	0.039989	0.038162	0.040661

References

1. Borch, Karl. "Indifference Curves and Uncertainty", Swedish Journal of Economics, LXX, No. 1 (March 1968), 19-24.

2. Jensen, Michael C. "The Performance of Mutual Funds in the Period 1945-1964", Journal of Finance, XXIII (May 1968), 389-416.

3. Lintner, John. "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets", Review of Economics and Statistics, XLVII (February 1965), 13-37.

4. Mossin, Jan. "Equilibrium in a Capital Asset Market", Econometrica, XXXIV (October 1966), 768-83.

5. Sharpe, William F. "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk", Journal of Finance, XIX (September 1964), 425-42.

6. Treynor, Jack L. "Toward a Theory of Market Value of Risky Assets" (unpublished manuscript, undated).

7. TROLL Manuals. Computer Research Center for Economic and Management Science, National Bureau of Economic Research, Inc.

8. Breiman, Leo. "Statistics with a View Towards Applications". Houghton - Mippliu Co., Boston,December 5, 1973.

9. Draper, Norman, and Harry Smith, " Applied Repression Analysis", John Wiley and Sons Inc., New York, 1966.

10. Fama, Eugene L. and Norman II. Miller , New York, Holt,Rinehart and Winston, 1972.

Date Due

BASEMENT

NOV 5 1986

MAR 17 '88

Lib-26-67

T-J5 143 w no.921- 77
Barnett, Arnol/Crime and capital punis
731204 D*BKS 00035432
3 9080 000 840 576

T-J5 143 w no.922- 77
Naim, Moise. /Ideology, dependencia a
731206 D*BKS 00035433
3 9080 000 840 618

MIT LIBRARIES DUPL
923-77
3 9080 004 584 154

T-J5 143 w no.924- 77
Berman, Oded. /Robust regression and s
731210 D*BKS 00035434
3 9080 000 840 634